with respect to it by inserting into it multiple prongs, in a way similar to that used for the top whipstock of Case 1. The order in which stacked holes are drilled and completed may be either from the bottom up or from the top down. In an alternative procedure, the supporting packer is released after completion of each hole or drainhole and successively reset and re-oriented at a different depth for each of the other holes or drainholes. Again the whipstocks are handled by appropriate overshot latching tools, preferably equipped with end milling cutters to remove any protruding obstruction.

The second method again uses a special casing patch, shown on FIG. 11, with an open elliptical window (65). The casing patch is set in the casing by slips above and below an interval over which the casing was milled out. The casing patch includes a pre-oriented whipstock packer (31) in its lower part. It may also be run-in with the retrievable whipstock (32) already in place. After setting the hanger slips (14), the drilling bit and drill string, guided by the whipstock through the open elliptical window, are used to drill the side-tracked hole and operations continue as in Case 4.

This is the preferred embodiment for deep wells, because it provides the largest diameter drainholes, for the minimum casing diameter, provided that cementation problems are not likely in the type of formation existing at the drainholes kick-off points.

CASE 6a (FLOW THROUGH A SYPHON IN EXISTING CASING)

The existing casing, with its perforations plugged off, constitutes the oil sump required as the downwards leg of the syphon (see FIG. 11). The production tubing must extend to the bottom of the sump, where the pump is located, as in Case 6.

Drilling, gravel packing, tie-in and cementing of the drainholes may be obtained by any of the methods described in Cases 1a, 2a, and 4a.

For instance, the twin whipstock used in Case 1a includes a flow-through hole connected to a tail pipe (66) equipped with a pump receiver nipple joint (67) at the bottom. The upper face of the hole also serves to receive one of the alignment pins (8) of the retrievable top whipstock. This hole is also terminated by a polished bore receptacle (10) in which the production tubing stinger, equipped with chevron seals, will be stabbed prior to setting the packer, as in Case 6.

The only difference is that a casing patch is now used instead of a special casing joint. Hangers (14) are used instead of threaded connections.

The tubing completion assembly and its installation procedures are identical with those of Case 6.

Using the drainhole drilling and tie-in method of Case 2a, the only modification required is the drilling of a vertical hole through the cement and drillable casing plug after cementation of the two intermediate liners, to provide access into the oil sump through which the production tubing will be inserted. The tubing completion assembly of Case 6 is simplified because the tail pipe terminated with its pump anchoring nipple joint is threaded directly into the bottom face of the dual string packer.

The drainhole drilling and tie-in procedures of Case 4a remain unchanged, but the tubing completion assembly is the same as in Case 6.

CASE 7a (DUAL PUMPING IN WORK-OVER WELL)

The production tubing assembly is the same as in Case 7. It can be used with any of the well configurations resulting from the drainhole drilling and tie-in methods of Cases 1a, 2a and 4a.

CASE 8a ("HUFF AND PUFF" MODE OF OPERATION IN WORK-OVER WELL)

The tubing completion assembly is similar to that in Case 8. (see FIG. 12). In principle, all the drilling and tie-in methods of Cases 1a, 2a and 4a are applicable, provided that the inside diameter of the insert or casing patch is sufficient to accomodate two drainhole tubing strings below the packer, when the pump is located above the packer, and three tubing strings when pumping is through a syphon.

With the two drainholes operated in "huff and puff" known downhole wireline retrievable three-way valves are also included in the tubings in a valve nipple joint. The valve nipple joints (55), connected to the lower branches of the Y are then below the hanger, so their hydraulic control lines (56) also pass through and extend below the hanger (14).

If dual pumps located in the drainholes are used (see FIG. 13), the one located in the injection drainhole is pulled out of its seat (e. g. a progressive cavity pump) or pumped out (e. g. a casing-free type jet pump) prior to switching the drainhole to the injection mode. Each type of pump is actuated through its own side entry conduit The side entry of the rod string or that of the power fluid tubing is always located below the valve nipple, so as not to interfere with the valve operation while unsealing the pump.

The pumped production stream in the annulus between liner and rod string is discharged through the side port of the valve into the casing/injection tubing annulus. A casing packer is no longer required, but a 3 or 4 string hanger (69) is used instead. When the Y nipple joint is below the hanger, three strings are required, respectively connected to—the upper branch of the Y,

both of the side-entry conduits (68) through which the rotating rod strings (70) driving progressive cavity pumps are inserted.

When hydraulic or jet pumps are used, the power fluid, pumped from the surface through a single tubing stabbed into a receptacle above the hanger is also fed to the pumps in all drainhole liners by means of twin conduits leading respectively to each of the two side entry points. It is through those conduits that smaller power fluid tubings are inserted into the drainhole liners, with a pump linked to each of them. The production stream from each drainhole, mixed with the spent power fluid is then discharged into the annulus between liner and power fluid tubing to ultimately reach the casing annulus where it is commingled with that of the other drainholes and conveyed to the surface.

When the the Y nipple joint is above the hanger, the valve nipples may then also be above the hanger, together with their control lines. On the other hand, the two lower branches of the Y and the corresponding two side entry conduits require that a 4 string hanger be used.

In all cases, however, the tubing completion assembly may be run-in and set in the casing in a single trip, even in the most complex configurations of Cases 8 or 8a.

I claim:

1. Apparatus for completing a multi-branch cased well for oil recovery by sequential cyclic steam injection methods

and for petroleum production from non-uniformly-pressured heterogeneous reservoirs through medium curvature, liner-equipped, horizontal drainholes;

said apparatus includes downhole equipment, tools and devices for making casing/liner and liner tubing sealed connections and individual liner/drainhole flow connections, comprising:

a) a special steel casing joint equipped with a hard metal multi-channel whipstock permanently affixed to and sealed in said casing joint by means of an upper guide plate presenting at least two small feed-through vertical holes, one of which terminated at both ends by threaded connections, and two larger vertical holes, each leading to a slanted cylindrical curved channel partly filled with a cement plug and each said channel leading to an elliptical window machined in a direction slanted downwards at a pre-selected kick-off angle into the wall of said casing joint and plugged by a drillable plate conforming with the outer surface of said casing joint,

b) a retrievable wedge-type top whipstock tool whose base presents at least two alignment pins or prongs fitting into said guide plate small holes, in which they are held by releasable latches, said top whipstock's outer lateral surface presenting at least one latching recess for its removal using an overshot tool,

c) an overshot tool equipped with releasable hooks to pull out, re-orient and reset said top whipstock, in the same trip,

d) a steel liner inserted in a drainhole drilled through each said whipstock channel, said liner hung with devices resisting liner weight and thermal expansion forces applied to said liner from above as well as from below and said liner permanently sealed into said channel by a pressure-sealing device including a heat-resistant seal, in addition to thermal cement,

e) a tubing completion assembly conveying production fluids from a drainhole to the surface and steam from the surface to a drainhole; wherein said tubing completion assembly is terminated, at its lower end, by a heat-resistant, pressure-tight, multiple-breakable-sealed connecting device wherein two pairs of vertical tubular connector prongs, equipped with releasable high-temperature-sealing devices, respectively fit into the two larger holes and into the two smaller holes in the guide plate of said special casing joint, to respectively convey production fluids from a drainhole to said tubing assembly and steam from a known three-way valve to the other drainhole,

f) a hydraulically-operated slot-cutting tool for selectively perforating said drainhole liner to establish a flow connection between a surrounding oil reservoir and said liner in its uncemented lower part.

2. Apparatus for completing a multi-branch cased well for oil recovery by sequential cyclic steam injection methods and for petroleum production from non-uniformly-pressured heterogeneous reservoirs through medium curvature, liner equipped, horizontal drainholes;

said apparatus includes downhole equipment, tools and devices for making casing/liner and liner/tubing sealed connections and individual liner/drainhole flow connections, comprising:

a) a special steel cylindrical casing joint presenting an elliptical side window machined at a prescribed small downwards kick-off angle and covered by a drillable metal plate shaped to conform with the outer surface of said casing joint which is also equipped with a drillable orientation device comprising a vertical key or groove,

b) a drillable support and packer affixed in said casing joint by slips below said window,

c) a retrievable single-channel whipstock tool set within said packer in accordance with a matching orientation device;

said whipstock presents at least one guiding groove on its slanted surface and at least one latching recess on its cylindrical surface,

d) a short intermediate steel liner of a diameter slightly smaller than said window's short axis, allowing its insertion into a kicked-off hole, through the window and wherein the upper end of said intermediate liner is equipped with a pressure-sealing gasketed drillable collar shaped to conform both with the inner surface of the casing joint along the edge of the window and with said guiding groove in the whipstock, so that said gasketed end, when pressed against the the inner surface of the casing joint, provides a permanent high-temperature seal in addition to thermal cement around said intermediate liner,

e) an overshot tool, equipped internally with at least one spring-loaded hook to latch into the whipstock's latching recess or key and pull it out; said tool also presents at its lower end some milling cutters, for surfacing the liner's drillable collar and for drilling-out the packer slips and support, and said tool includes a latching device, for pulling-out the drilled-out packer,

f) a selectively perforated drainhole steel liner inserted in a drainhole drilled through such intermediate liner, hung from above as well as from below and cemented in the lower part of said intermediate liner, and having the annular space between intermediate liner and drainhole liner sealed with an inflatable packer,

g) a tubing completion assembly conveying production fluids from a drainhole to the surface and steam from the surface to a drainhole, wherein said tubing completion is terminated at its lower end by a heat-resistant, pressure-tight, multiple-breakable-sealed connecting device wherein several articulated connector steel tubes are each inserted into the upper part of the intermediate liner of a drainhole, and the annular space between the inner surface of said intermediate liner and said connector tube is sealed by an inflatable thermal packer,

h) a hydraulically-operated slot-cutting tool for selectively perforating the uncemented lower part of each drainhole liner.

3. Apparatus for completing a multi-branch cased well for oil recovery by sequential cyclic steam injection methods and for petroleum production from non-uniformly-pressured heterogeneous reservoirs through medium curvature, liner-equipped, horizontal drainholes;

said apparatus includes downhole equipment, tool and devices for making multiple casing/liner and liner/tubing sealed connections and individual liner/drainhole flow connections, comprising:

a) at least one special casing joint in the casing string of a vertical hole, opposite a reamed interval straddling the kick-off points of one or more drainholes, said joint presenting one or more elliptical windows oriented downwards and facing pre-selected kick-off directions at various depths,

b) a telescopic steel liner stub closed at its lower end by a drillable metal plate plugging each window, and machined at both ends to conform respectively with the outer surface of the casing window for the lower end and with the inner surface of the casing window for the upper end,

c) two drillable metal guide cages supporting said stub, inclined at the kick-off angle, with one of the two guide cages affixed inside the casing joint by drillable fasteners while the other, freely inserted into the stub, is mobile and can slide within said fixed guide over an interval equal to a fraction of the stub length,

d) a drillable gasketed collar affixed to the stub's upper end to prevent said telescopic stub's upper end from popping out through the window into the reamed cavity when the stub is extended by increasing the hydraulic pressure in the casing with respect to that of the annulus during cementation of the casing string and of each extended stub, with a cement slurry displaced behind the casing and wherein said gasketed collar presents at least one guiding key or groove sliding along a bar of the fixed guide cage, to prevent any rotation of the stub around its axis,

e) a steel liner inserted in a drainhole drilled through such a liner stub, permanently hung by a dual hanger's opposing slips into said stub and sealed with a high-temperature pressure-sealing device, in addition to thermal cement,

f) a tubing completion assembly, conveying production fluids from a drainhole to the surface and steam from the surface to a drainhole, having at its lower end a heat-resistant, pressure-tight, multiple-breakable-sealed connecting device wherein telescopic connector steel tubes inclined at the kick-off angle are facing each window, with the tube's lower end equipped with a high-temperature sealing device insertable into the upper part of the window's stub and set when said connector tube is in its extended position, whereas the upper end of said tube is equipped with a movable sliding seal remaining within a cylindrical cavity of said tubing completion assembly,

g) a hydraulically-operated slot-cutting tool for selectively perforating the uncemented lower part of each drainhole liner.

4. The apparatus for completing a multi-branch cased well of claims 1, 2 or 3 wherein the hydraulically-operated slot-cutting tool comprises:

a) a cylindrical tool body inserted into said drainhole liner wherein a plurality of cutting wheels, each one mounted on a perpendicular axis to that of said body, at the end of an hydraulically-operated articulated arm, are periodically pressed into the inner surface of said liner wall, which they penetrate, by large forces applied only when the arms are extended by the displacement of a spring-loaded hydraulic piston sliding in a pressurized liquid-filled cylinder,

b) a source of periodic hydraulic fluid pressure at the surface,

c) a coiled tubing of smaller diameter than that of said drainhole liner, connecting said cylindrical body to said pressure source and providing a mechanical link to the surface, to insert and pull-out the tool body through the liner, thus causing each cutting wheel to cut a slot into the liner wall, substantially parallel to the axis of said liner, while the arms are kept in their extended position, but leaving the liner wall intact when the arms are brought into their retracted position along the tool body.

5. The apparatus for completing a multi-branch cased well of claim 3, wherein the tubing completion assembly comprises a multiple-breakable-sealed connecting device presenting at least two slightly inclined fixed branches, each one terminated by a connector tube assembly equipped at its end with a known sealing device, taken from a list comprising: thermal packings, O rings and metal/metal seals, to provide a breakable pressure-seal against the inner surfaces of said casing/liners's connecting device;

said connector tube assembly comprises:

a) a cylindrical body with its upper end connected to a tubing and forming with said tubing an angle equal to that formed by the casing/liner connecting device and the casing, and said upper end equipped with anchoring means to fasten it to the inner surface of the casing,

b) a connector steel tube sliding through said cylindrical body under the surface-controlled pressure of a hydraulic fluid which also compresses a spring against an arrestor ring, to provide a spring-loaded, high-temperature end seal of said connector tube when in its extended position,

c) a wireline-releasable mechanical latch maintaining said spring under compression after the hydraulic pressure has been released.

d) means for latching a suitable retrieval wireline tool to the tail end of said connector tube to retract it and to latch it into said body in its retracted position, in the event that the whole tubing completion assembly has to be pulled out for inspection or repairs,

e) a packing-type, high-temperature lateral seal in the annulus between said cylindrical body and the tube within said connector tube assembly, providing a breakable pressure-sealed flow connection between said liner and said tubing.

f) a packing-type, heat-resistant seal around said connector tube, above said end seal, providing an additional pressure-seal against the inner surface of the casing/liner connecting device in which the connector tube is inserted.

6. The apparatus for completing a multi-branch cased well according to claims 1, 2 or 3 further comprising a downhole pump and means for preventing pump cavitation and gas lock in the tubing completion assemblies, when they convey gassy or boiling production fluids to the surface;

said means comprising:

1) a vertical sump, closed at its top by a conventional multi-string tubings/casing packer and connected to said multiple drainholes, and wherein the absolute flowing pressure of said produced fluids, at the point of highest elevation in the flow path from the drainholes to said sump, may drop below the bubble point absolute pressure of said fluids, a situation resulting in gases being evolved or coming out of solution to form a gas pocket which interrupts the flow of liquids from said drainholes into the sump pump,

2) a wireline-retrievable gas-purging device suitable for latching into the short string of the multi-string packer located at the top of the sump, wherein said device is taken from a downhole equipment list comprising:

a) a normally closed subsurface valve whose opening is controlled by a fluid level sensor at the top of said oil sump to periodically purge into the compartment above said packer any gas phase accumulating above a predetermined fluid level depth.

b) a wireline-retrievable plug in said packer, comprising a permselective membrane permeable to diffusing gas but impervious to liquid flow, for continuously purging of said gas phase, under a gas pressure gradient,

c) a venturi in the pump-discharged liquid production stream flowing through a string adjacent to said plug in said multi-string packer, at its exit into an enlarged flow cross section above said packer, which is equipped with a gas flow connection between the side of said venturi and the upper face of said membrane, to create said gas pressure gradient.

7. A method for drilling and completing a multi-branch cased well for oil recovery by sequential cyclic steam injection methods and for petroleum production from non-uniformly pressured heterogeneous reservoirs through medium-curvature, liner-equipped, horizontal drainholes, wherein casing/liner connections are permanently-sealed, wherein liner/tubing are connected by breakable-seals, and comprises the following steps:

a) drilling a pair of short deviated boreholes through the bottom of said vertical well casing,

b) inserting in said pair of drainholes two short intermediate steel liners using a work string ended with an inverted Y nipple joint, two articulated nipple joints, each one equipped with a rubber cementing seal cup, and holding said intermediate liner with a releasable latch,

c) stab-in cementing of said two short intermediate liners using said work string as cementing string, with sufficient overlap of a special high-temperature resin cement in the casing to provide a permanent gas-tight thermal tie-in of the casing with each intermediate liner,

d) drilling successively each drainhole through each intermediate liner,

e) running a coiled-tubing steel liner through each said intermediate liner into said drilled drainhole, affixing it to the intermediate liner with a dual hanger's opposing slips and with a high-temperature pressure-sealing device prior to cementing its upper end to the intermediate liner's lower end, with a known thermal cement,

f) connecting the upper part of each intermediate liner to the lower end of a tubing assembly equipped with a heat-resistant pressure-tight, multiple-breakable-sealed connecting device,

g) selectively perforating the uncemented lower part of said coiled tubing liner "in situ" using a hydraulically-operated slot-cutting tool at the end of a smaller-diameter coiled-tubing run-in from the surface and inserted through said tubing assembly and intermediate liner into said drainhole liner.